CHARACTERIZATION OF AUXETIC AND MECHANICAL BEHAVIOURS OF AUXETIC COMPOSITES DEVELOPED USING STAR KNITTED STRUCTURES

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ABSTRACT

This work evaluates the auxetic behaviour of composite materials produced from weft-knitted fabrics made from high-tenacity para-aramid (p-AR) and polyamide 6.6 (PA) fibres, which have proven to present negative Poisson's ratios (NPR). Composites were produced by reinforcing an epoxy resin with those developed fabrics and the degree to which they were able to preserve the previous auxetic behaviour of the fibrous reinforcements investigated in order to obtain a new type of auxetic materials, reinforced with re-entrant star designed fabrics, that could present higher mechanical performance due to its NPR behaviour.

INTRODUCTION

Many of the mostly important mechanical properties of conventional materials, such as fracture toughness and impact and indentation resistance, can be significantly improved through the use of auxetic materials. This has increased the opportunity of applying auxetic materials in highly demanding markets, such as the aerospace, automobile, sports and defense ones [1,2]. In this work, the mechanical properties were determined on epoxy matrix composites reinforced with auxetic knitted structures. An epoxy resin has been selected as matrix due to its excellent toughness, adhesion, thermal and chemical resistance [3]. The developed composites were submitted to tensile testing in order to determine their tensile strength and energy absorption until failure. Samples were also subjected to drop weight impact testing to evaluate their impact behaviour. Images taken from composites under tensile deformation were recorded, analysed and treated using a MatLab® high-performance software for assessing their auxetic behaviour.

MATERIALS AND EXPERIMENTAL PROCEDURE

An epoxy resin Biresin® CR83 combined (100:30 ratio) with hardener Biresin® CH83-2, both from Sika Deutschland GmbH / Germany, was used as matrix of the composites produced in this work. The tensile tests were carried out using an universal testing machine Hounsfield H 100 KS equipped with a 2.5 kN load cell at crosshead speed rate of 5 mm/min, accordingly to the ASTM D3039/D 3039M-00 standard. The impact tests were made by using a *Fractovis Plus*® drop weight impact testing equipment from Ceast, in accordance to the ASTM D7136/D7136M standard.

RESULTS AND CONCLUSIONS

Table 1 shows the following results obtained: weight gain after resin impregnation, composite thickness, maximum load and energy absorbed in the tensile tests and NPR measured in the composites. As it may be seen, the re-entrant star structures demonstrated to absorb higher energy than non-auxetic composite (plain grid). In regarding to NPR, the auxetic behaviour for

that structure was obtained in wale direction (vertical column of intermeshed needle loops). The composites reinforced with para-aramid yarns had lower NPR than those produced with polyamide yarns.

Table 1. Properties obtained in the different composites produced.

Sample Ref.	Weight gain after resin impregnation (%)	Thickness (mm)	Maximal Load (N)	Energy absorbed (J)	NPR
Plain Grid	48 (2)*	1,57 (12)	1338 (6)	56 (11)	-
Aux. PA	51 (4)	14,20 (6)	778 (15)	69 (16)	-0.17
Aux. p-AR	51 (3)	13,25 (7)	2489 (5)	120 (12)	-0.10

* the figures within the brackets are the CV (%) of results.

As Figure 1 clear shows, the Aux. p-AR composite exhibited superior strength and energy absorption. Furthermore, the mechanical strength of Aux. PA is notoriously lower than plain grid. Nonetheless, the Aux. PA presented a higher deformation at failure.

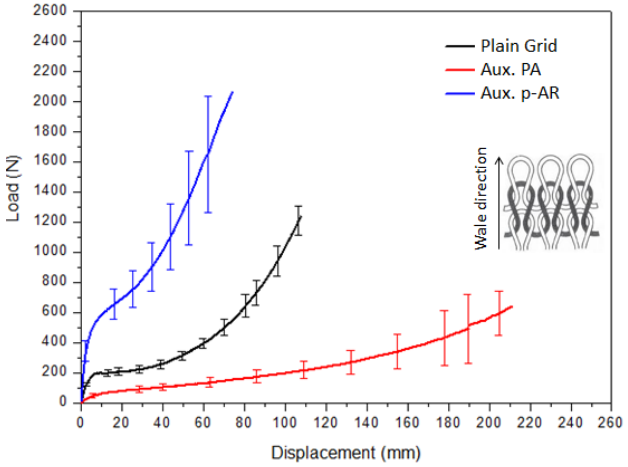

Figure 1. The average load-displacement curves for the composites tested.

Results obtained from the impact tests performed on the NPR composites developed will be also discussed and presented in order to evaluate their potential application in personal protection products, where energy absorption is a key factor to be considered.

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